LSF010XEVM-001

This document is the user's guide for the LSF010XEVM-001 Evaluation Module (EVM). The EVM allows for evaluation of the different ways that the LSF devices can be used to translate voltages between 1 V and 5.5 V.

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1 About This Manual

This user's guide describes the LSF010XEVM-001. This guide contains an introduction, setup instructions, the EVM schematic, top and bottom printed-circuit-board (PCB) layouts, and a bill of materials (BOM).

2 Information About Cautions and Warnings

The information in a caution or a warning is provided for your protection. Read each caution and warning carefully.

CAUTION

This EVM contains components that can potentially be damaged by electrostatic discharge. Always transport and store the EVM in its supplied ESD bag when not in use. Handle using an antistatic wristband. Operate on an antistatic work surface. For more information on proper handling, see the *Electrostatic Discharge* (ESD) application note (SSYA008).

3 Items Required for Operation

- Volt meter
- Oscilloscope
- Square wave signal source

4 Introduction

The LSF010XEVM-001 is an EVM board that contains 4 LSF voltage clamp translators: 1bit, 2-bit, 4-bit, and 8 bit. These translators are bi-directional and only the LSF0204 requires a control pin. They can accept voltages up to 5.5 V on the inputs and the output will be equal to the VrefA voltage. Once the output reaches the VrefA level it can then be pulled to any other level between VrefA and 5.5 V. When using multi-bit LSF devices you can have many different levels of voltage translation on the same part. They can translate at medium to high speeds up to 100 MHz and cover these common voltage nodes and anything in between (1 V, 1.2 V, 1.5 V, 1.8 V, 2.5 V, 3.3 V, and 5 V). These devices act like a switch when the input is between GND and Vref A and will have FET switch type characteristics such as speeds up to 200 MHz when translating down. Then the I/Os can be pulled up to any voltage between VrefA and 5.5 V. The maximum speed will then be limited by the size of the pull-up resistor and speeds up to 100 MHz can be achieved when translating up.

The LSF010XEVM-001 EVM allows simplified evaluation and prototyping without the need for full board development. This EVM provides peripheral header style pads for probing and signal connection to each device pin and can be plugged into any prototype board with DIP header spacing. The boards are scored so they can easily be broken apart.

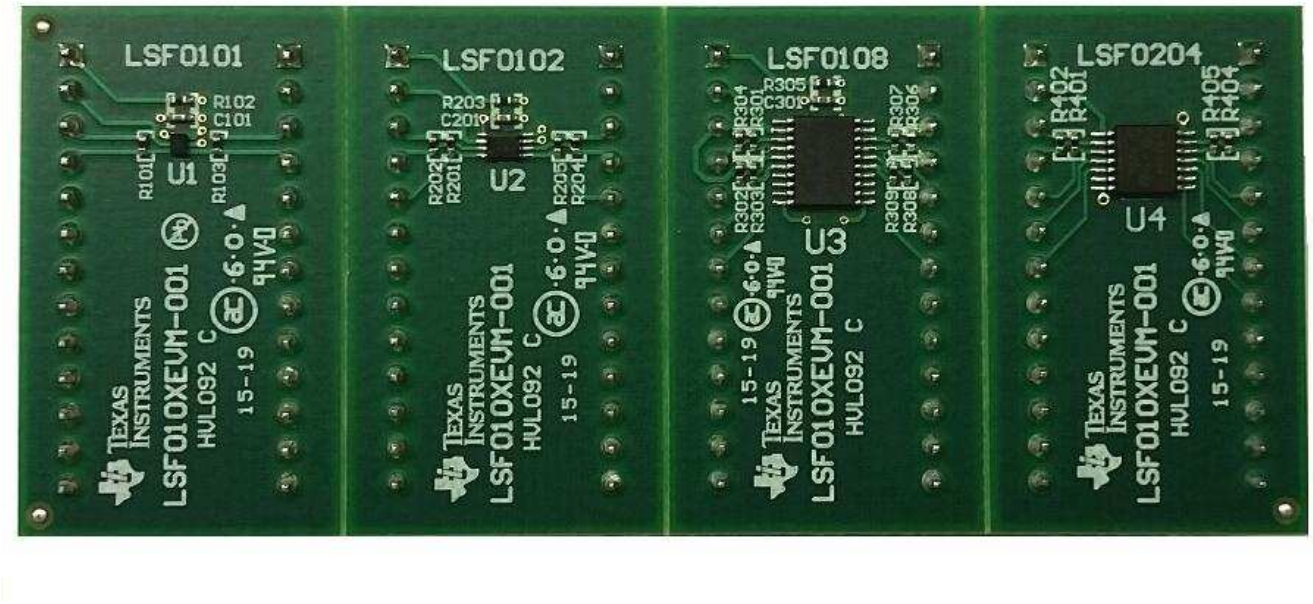

Figure 1. EVM Board

5 Setup

This section describes the setup and connections of the EVM boards and describes how to set up the boards for voltage translations in either up or down direction.

5.1 General Rules for Good Signal Integrity

Ensure that Vref_A , Vref_B and GND are all connected and configured properly. There should be a bypass capacitor on Vref_B (0.1 µF). When connecting signals, minimize the connection length and keep GND leads short when probing. This will ensure minimal capacitive, resistive and inductive loading caused by the connection and connector. For more device information please see the LSF0101, LSF0102, LSF0204, and LSF0108 device datasheet.

5.1.1 VCC and GND Connections

Vref_B is considered V_{CC} or device power. It will need to be 0.8 V greater than Vref_A. Vref_A will be the lowest voltage that the part can translate down to.

GND is connected to pin 1 of P2 (LSF0101), Pin 1 of P4 (LSF0102), Pin 1 of P6 (LSF0108), and Pin 1 of P8 (LSF0204). See connector pin locations in Figure 1 .

5.1.2 Translation Connections

On each board there will be a VAPU and a VBPU connection. These are the pull-up voltages that correspond to the voltage being translated. These pull-up voltages must be between or equal to VrefA and VrefB.

Some of the I/O pins on the LSF0108 will not have pull-up resistors. This will allow the use of different pull-up resistor values and voltages on the A or B side. The A and B pins can be pulled to different levels on each pin demonstrating that the part can translate many different voltage levels at the same time. (The pull-up resistors installed on the boards are 301 Ω)

The following are examples of how the parts can be set up:

Each of these tests can be performed on any of the boards.

NOTE: The LSF0101 and LSF0102 have all their pins connected to pull-up resistors on the EVM. The A and B pins without pull-up resistors on the LSF0108 are the only pins that can be pulled down.

Test examples
There can be multiple types of tests performed on each board. The drawing shows A as the input and B as the output; however, it can work either direction. The output on Aside or Bside will be limited to VrefA for a high level. Either side can then be pulled to any level between VrefA and 5.5 V. This allows up translation, down translation or any combination. The signals can go in both directions without the need for a direction pin.

Example 1 no pull-up
With no pull-up on either side (don't connect VAPU or VBPU), you will be able to translate down to VrefA going either direction. The input can be 0 V to 5.5 V and the output will be 0 V to VrefA. Either A-side or B-side can be the input. This method can be used for down translation.

Example 2 with pull-up
By connecting VAPU or VBPU, you can pull the A or B side to any level between VrefA and 5.5 V. This method can be used for up translation. By connecting the outputs to multiple pull-up levels you are able to translate to a variety of different voltage nodes using a single part. Testing the part using multiple pull-up voltages can only be done on the LSF0108 or LSF0204. The first four I/O's will be tied to the same pull-up voltage on the EVM. (VAPU or VBPU) The remaining I/Os can be connected to external pullup resistors and different pull-up voltages.

Example 3 with pull-down
A pull-down to GND can also be used which will give the output value of Vref_A. This is sometimes used to help with noise. If VREFA is the voltage that you are translating to then the pull-up can be tied to VREFA for another way to reduce noise.

Example 4 with open drain part (Figure 3)
This configuration allows you to control the input level with Vref. Using an open drain part on the input side will allow VrefA to control the input level. VBPU will control the output level of the LSF. Do not connect anything to VAPU. You can put in a 0 V to 5 V signal into the open drain part, a 2 V signal on Vref, and a 3.3 V signal on VBPU.

This will then translate from 5 V to 2 V on Abus and then to 3.3 V on B bus.

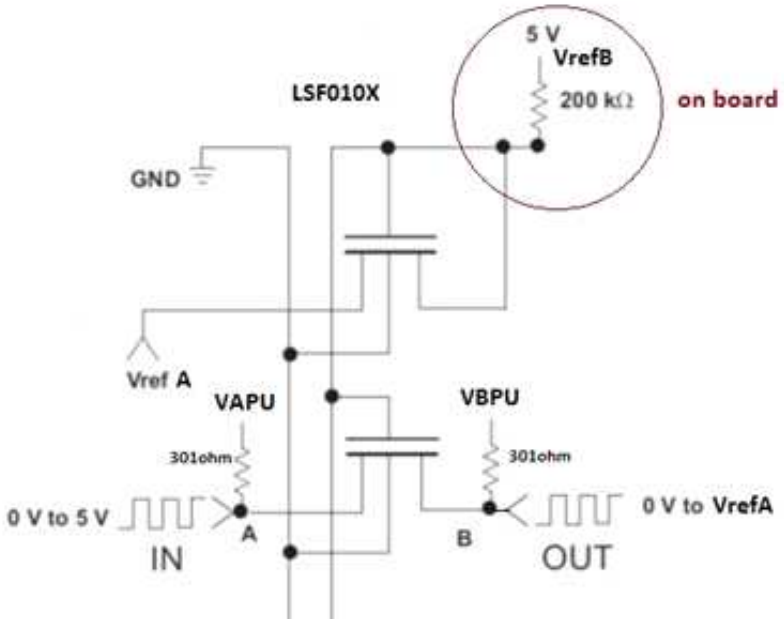

Figure 2. Pull-up Resistors on VAPU and VBPU (200kΩ integrated within LSF0204 device)

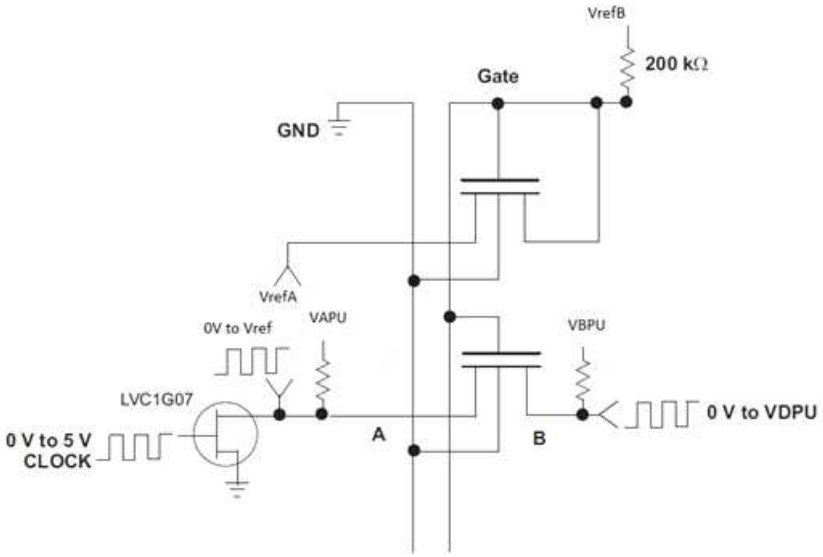

Figure 3. Open Collector Input Control Circuit

6 Schematic

The circuit diagrams in Figure 4 to Figure 7 show the schematics for the LSF010XEVM-001:

6.1 Board Schematics and Pin Layout

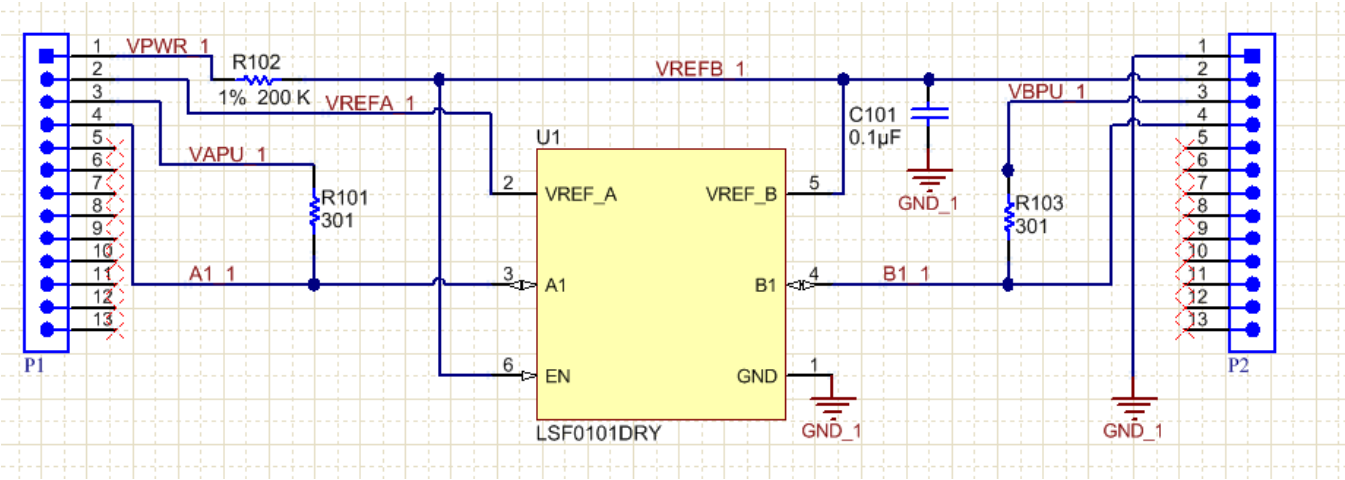

Figure 4. LSF0101 Schematic

Table 1. LSF0101

P1	Pin Out	P2	Pin Out
1	Power pin (Connect high-side supply here)	1	GND
2	Vref_A	2	Vref_B
3	VAPU A side pull-up	3	VBPU B side pull-up
4	A1 signal	4	B1 signal
5	NC	5	NC
6	NC	6	NC
7	NC	7	NC
8	NC	8	NC
9	NC	9	NC
10	NC	10	NC
11	NC	11	NC
12	NC	12	NC
13	NC	13	NC

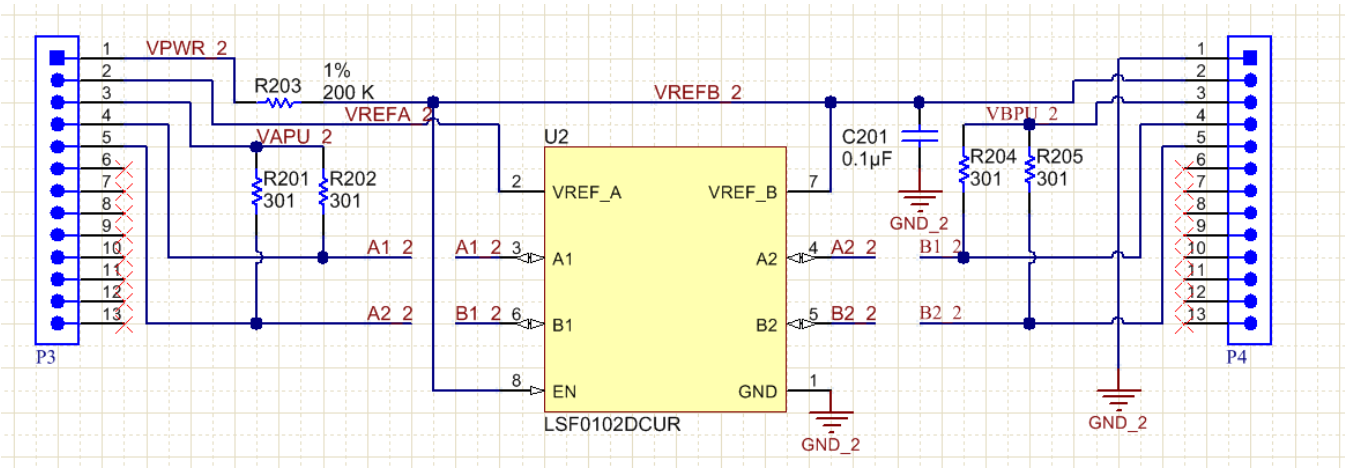

Figure 5. LSF0102 Schematic

Table 2. LSF0102

P3	Pin out	P4	
1	Power pin (Connect high-side supply here)	1	GND
2	Vref_A	2	Vref_B
3	VAPU A side pull-up	3	VBPU B side pull-up
4	A1 signal	4	B1 signal
5	A2 signal	5	B2 signal
6	NC	6	NC
7	NC	7	NC
8	NC	8	NC
9	NC	9	NC
10	NC	10	NC
11	NC	11	NC
12	NC	12	NC
13	NC	13	NC

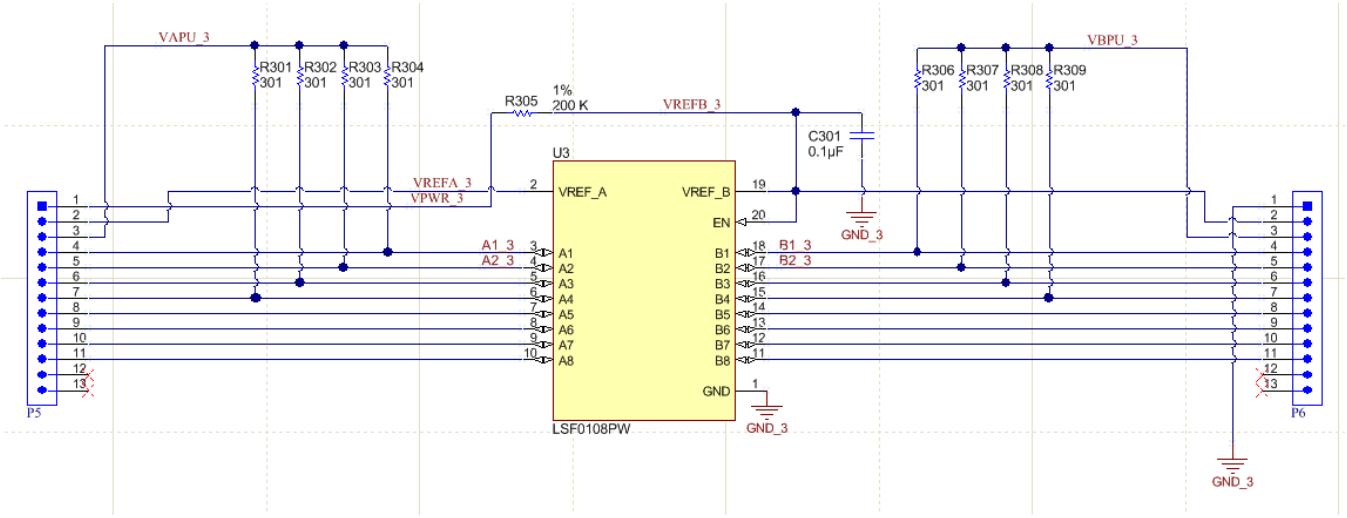

Figure 6. LSF0108 Schematic

Table 3. LSF0108

P5	Pin Out	P6	Pin Out
1	Power pin (Connect high-side supply here)	1	GND
2	Vref_A	2	Vref_B
3	VAPU A side pull-up	3	VBPU B side pull-up
4	A1 signal	4	B1 signal
5	A2 signal	5	B2 signal
6	A3 signal	6	B3 signal
7	A4 signal	7	B4 signal
8	A5 signal	8	A5 signal
9	A6 signal	9	A6 signal
10	A7 signal	10	A7 signal
11	A8 signal	11	A8 signal
12	NC	12	NC
13	NC	13	NC

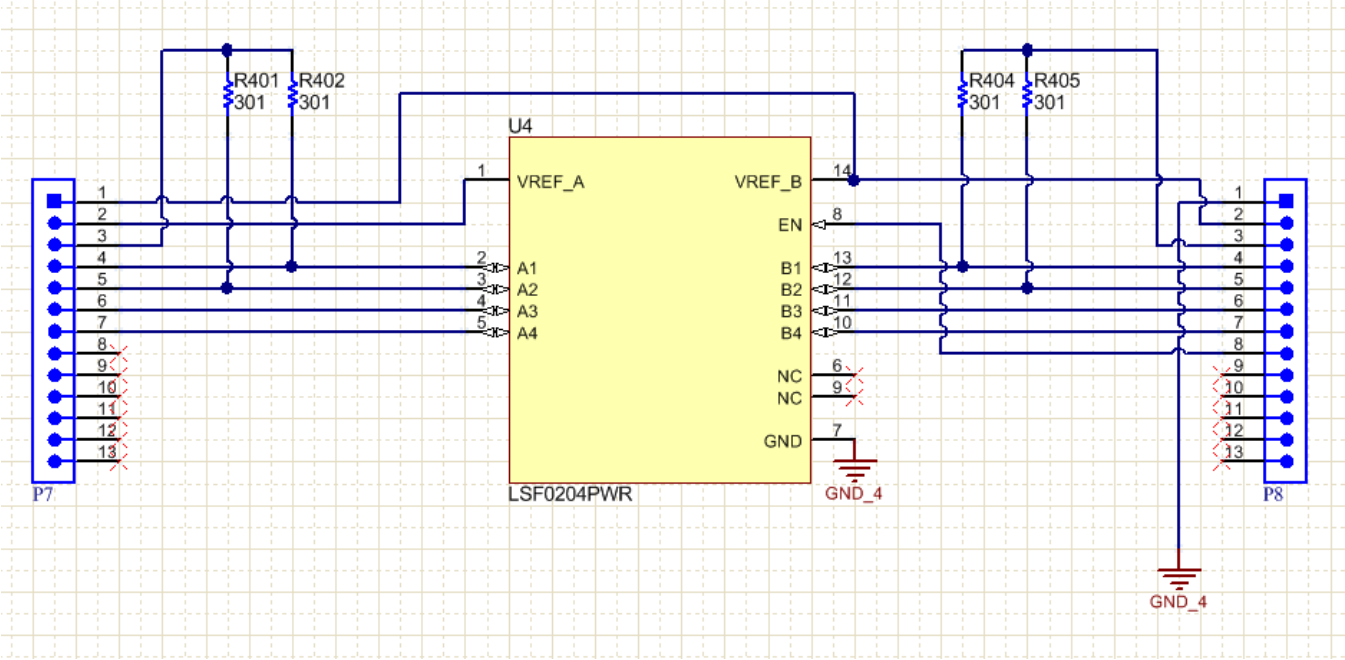

Figure 7. LSF0204 Schematic

Table 4. LSF0204

P5	Pin Out	P6	Pin Out
1	Power pin (Connect high-side supply here)	1	GND
2	Vref_A	2	Power pin (Connect high-side supply here)
3	VAPU A side pull-up	3	VBPU B side pull-up
4	A1 signal	4	B1 signal
5	A2 signal	5	B2 signal
6	A3 signal	6	B3 signal
7	A4 signal	7	B4 signal
8	NC	8	EN pin
9	NC	9	NC
10	NC	10	NC
11	NC	11	NC
12	NC	12	NC
13	NC	13	NC

7 PCB Board Layout

Figure 8 and Figure 9 illustrate the PCB layout.

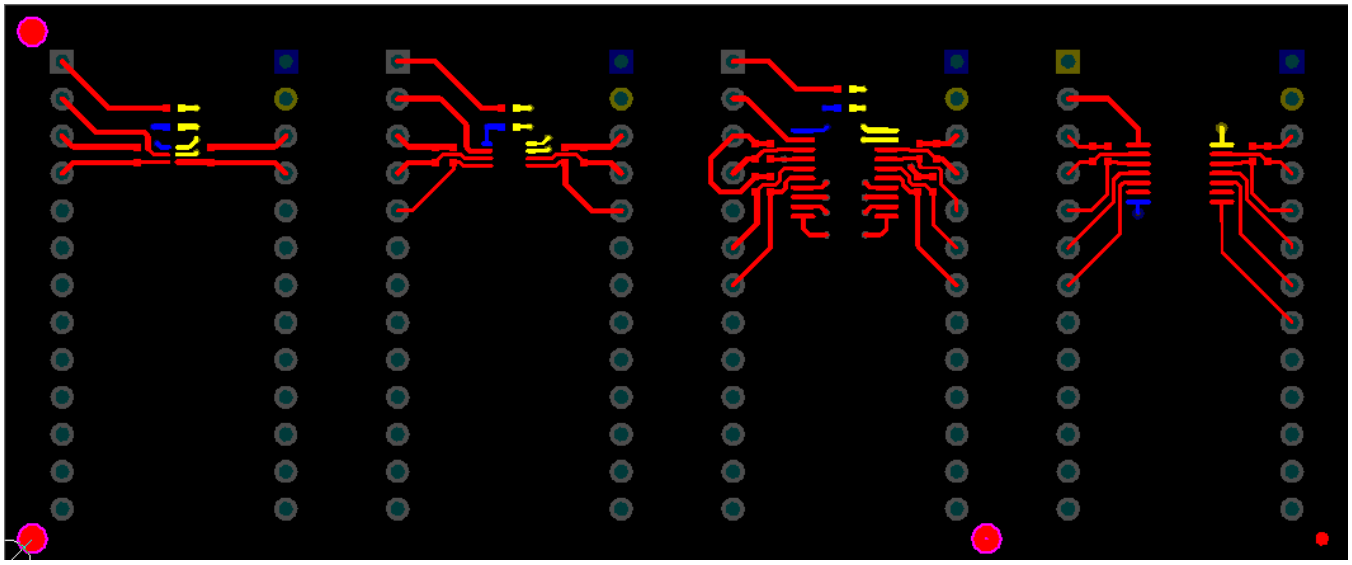

Figure 8. PCB Layer 1 (Top Layer)

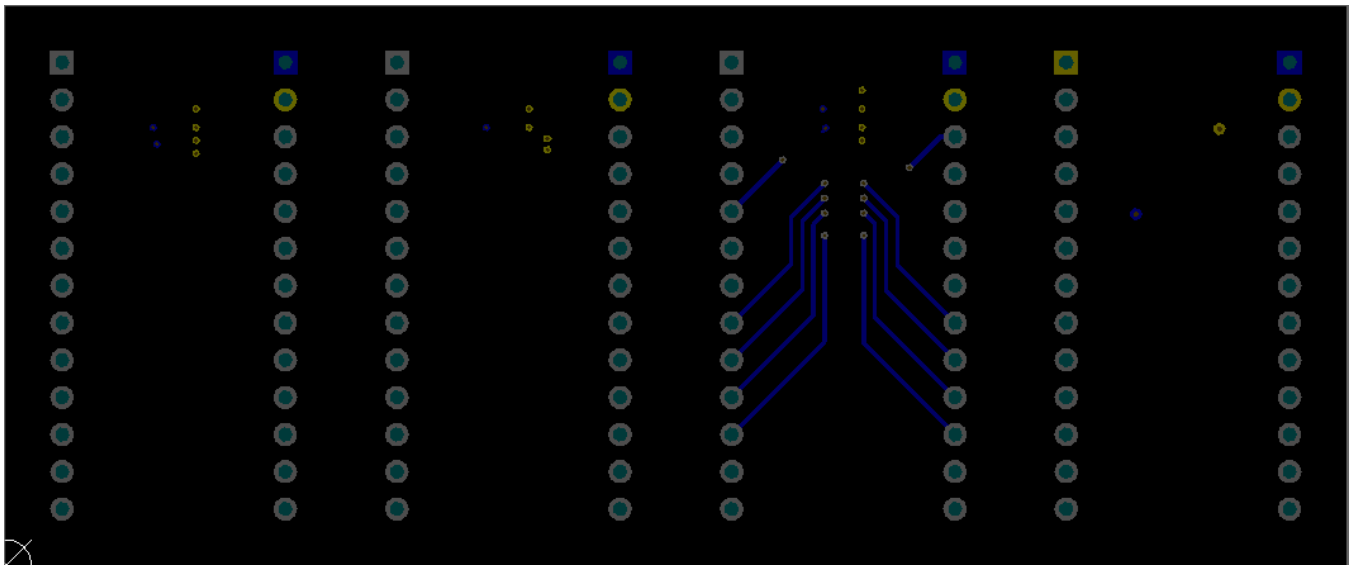

Figure 9. PCB (Bottom Layer)

8 Bill of Materials (BOM)

Figure 10 lists the BOM for the LSF EVM.

Designator	Quantity	Value	Description	PackageRef	PartNumber	Manufacturer
C101, C201, C301	3	0.1uF	CAP, CERM, 0.1uF, 50V, +/-10%, C0G/NP0, 0402	0402	C1005X7R1H104K	TDK
P1, P2, P3, P4, P5, P6, P7, P8	8		Header, 100mil, 13x1, Gold, TH	13x1 Header	TSW-113-07-G-S	Samtec
R101, R103, R201, R202, R204, R205, R301, R302, R303, R304, R306, R307, R308, R309, R401, R402, R404, R405	18	301	RES, 301 ohm, 1%, 0.063W, 0402	0402	CRCW0402301RFKED	Vishay-Dale
R102, R203, R305	3	200 K	RESISTOR, 0402, 200K, 1%	0402	CRCW0402200KFKED	Vishay-Dale
U1	1		1-Channel Bidirectional Multi-Voltage Level Translator for Open-Drain & Push-Pull Application, DRY0006A	DRY0006A	LSF0101DRY	Texas Instruments
U2	1		2-Channel Bidirectional Multi-Voltage Level Translator for Open-Drain & Push-Pull Application, DCU0008A	DCU0008A	LSF0102DCUR	Texas Instruments
U3	1		8 Channel Bidirectional Multi-Voltage Level Translator for Open-Drain and Push-Pull Application, PW0020A	PW0020A	LSF0108PW	Texas Instruments
U4	1		4-Bits Bidirectional Multi-Voltage Level Translator for Open-Drain and PushPull Application, PW0014A	PW0014A	LSF0204PWR	Texas Instruments

Figure 10. BOM

Revision History

Changes from Original (February 2010) to A Revision **Page**

- Added fourth device (LSF0204) globally. 2
- Changed *EVM Board* graphic to Rev. C of the EVM. 3
- Changed schematics for each of the four pieces of the EVM board. 6
- Changed layout pictures for top and bottom PCB layer. 10
- Changed BOM table. 11

NOTE: Page numbers for previous revisions may differ from page numbers in the current version.

STANDARD TERMS AND CONDITIONS FOR EVALUATION MODULES

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   1.1 EVMs are intended solely for product or software developers for use in a research and development setting to facilitate feasibility evaluation, experimentation, or scientific analysis of TI semiconductors products. EVMs have no direct function and are not finished products. EVMs shall not be directly or indirectly assembled as a part or subassembly in any finished product. For clarification, any software or software tools provided with the EVM (“Software”) shall not be subject to the terms and conditions set forth herein but rather shall be subject to the applicable terms and conditions that accompany such Software

   1.2 EVMs are not intended for consumer or household use. EVMs may not be sold, sublicensed, leased, rented, loaned, assigned, or otherwise distributed for commercial purposes by Users, in whole or in part, or used in any finished product or production system.

2 *Limited Warranty and Related Remedies/Disclaimers*:

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   2.2 TI warrants that the TI EVM will conform to TI's published specifications for ninety (90) days after the date TI delivers such EVM to User. Notwithstanding the foregoing, TI shall not be liable for any defects that are caused by neglect, misuse or mistreatment by an entity other than TI, including improper installation or testing, or for any EVMs that have been altered or modified in any way by an entity other than TI. Moreover, TI shall not be liable for any defects that result from User's design, specifications or instructions for such EVMs. Testing and other quality control techniques are used to the extent TI deems necessary or as mandated by government requirements. TI does not test all parameters of each EVM.

   2.3 If any EVM fails to conform to the warranty set forth above, TI's sole liability shall be at its option to repair or replace such EVM, or credit User's account for such EVM. TI's liability under this warranty shall be limited to EVMs that are returned during the warranty period to the address designated by TI and that are determined by TI not to conform to such warranty. If TI elects to repair or replace such EVM, TI shall have a reasonable time to repair such EVM or provide replacements. Repaired EVMs shall be warranted for the remainder of the original warranty period. Replaced EVMs shall be warranted for a new full ninety (90) day warranty period.

3 *Regulatory Notices:*

   3.1 *United States*

      3.1.1 *Notice applicable to EVMs not FCC-Approved:*

      This kit is designed to allow product developers to evaluate electronic components, circuitry, or software associated with the kit to determine whether to incorporate such items in a finished product and software developers to write software applications for use with the end product. This kit is not a finished product and when assembled may not be resold or otherwise marketed unless all required FCC equipment authorizations are first obtained. Operation is subject to the condition that this product not cause harmful interference to licensed radio stations and that this product accept harmful interference. Unless the assembled kit is designed to operate under part 15, part 18 or part 95 of this chapter, the operator of the kit must operate under the authority of an FCC license holder or must secure an experimental authorization under part 5 of this chapter.

      3.1.2 *For EVMs annotated as FCC – FEDERAL COMMUNICATIONS COMMISSION Part 15 Compliant:*

      CAUTION

      This device complies with part 15 of the FCC Rules. Operation is subject to the following two conditions: (1) This device may not cause harmful interference, and (2) this device must accept any interference received, including interference that may cause undesired operation.

      Changes or modifications not expressly approved by the party responsible for compliance could void the user's authority to operate the equipment.

      FCC Interference Statement for Class A EVM devices

      NOTE: This equipment has been tested and found to comply with the limits for a Class A digital device, pursuant to part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference when the equipment is operated in a commercial environment. This equipment generates, uses, and can radiate radio frequency energy and, if not installed and used in accordance with the instruction manual, may cause harmful interference to radio communications. Operation of this equipment in a residential area is likely to cause harmful interference in which case the user will be required to correct the interference at his own expense.

FCC Interference Statement for Class B EVM devices

NOTE: This equipment has been tested and found to comply with the limits for a Class B digital device, pursuant to part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference in a residential installation. This equipment generates, uses and can radiate radio frequency energy and, if not installed and used in accordance with the instructions, may cause harmful interference to radio communications. However, there is no guarantee that interference will not occur in a particular installation. If this equipment does cause harmful interference to radio or television reception, which can be determined by turning the equipment off and on, the user is encouraged to try to correct the interference by one or more of the following measures:

- *Reorient or relocate the receiving antenna.*
- *Increase the separation between the equipment and receiver.*
- *Connect the equipment into an outlet on a circuit different from that to which the receiver is connected.*
- *Consult the dealer or an experienced radio/TV technician for help.*

3.2 *Canada*

3.2.1 *For EVMs issued with an Industry Canada Certificate of Conformance to RSS-210*

Concerning EVMs Including Radio Transmitters:

This device complies with Industry Canada license-exempt RSS standard(s). Operation is subject to the following two conditions: (1) this device may not cause interference, and (2) this device must accept any interference, including interference that may cause undesired operation of the device.

Concernant les EVMs avec appareils radio:

Le présent appareil est conforme aux CNR d'Industrie Canada applicables aux appareils radio exempts de licence. L'exploitation est autorisée aux deux conditions suivantes: (1) l'appareil ne doit pas produire de brouillage, et (2) l'utilisateur de l'appareil doit accepter tout brouillage radioélectrique subi, même si le brouillage est susceptible d'en compromettre le fonctionnement.

Concerning EVMs Including Detachable Antennas:

Under Industry Canada regulations, this radio transmitter may only operate using an antenna of a type and maximum (or lesser) gain approved for the transmitter by Industry Canada. To reduce potential radio interference to other users, the antenna type and its gain should be so chosen that the equivalent isotropically radiated power (e.i.r.p.) is not more than that necessary for successful communication. This radio transmitter has been approved by Industry Canada to operate with the antenna types listed in the user guide with the maximum permissible gain and required antenna impedance for each antenna type indicated. Antenna types not included in this list, having a gain greater than the maximum gain indicated for that type, are strictly prohibited for use with this device.

Concernant les EVMs avec antennes détachables

Conformément à la réglementation d'Industrie Canada, le présent émetteur radio peut fonctionner avec une antenne d'un type et d'un gain maximal (ou inférieur) approuvé pour l'émetteur par Industrie Canada. Dans le but de réduire les risques de brouillage radioélectrique à l'intention des autres utilisateurs, il faut choisir le type d'antenne et son gain de sorte que la puissance isotrope rayonnée équivalente (p.i.r.e.) ne dépasse pas l'intensité nécessaire à l'établissement d'une communication satisfaisante. Le présent émetteur radio a été approuvé par Industrie Canada pour fonctionner avec les types d'antenne énumérés dans le manuel d'usage et ayant un gain admissible maximal et l'impédance requise pour chaque type d'antenne. Les types d'antenne non inclus dans cette liste, ou dont le gain est supérieur au gain maximal indiqué, sont strictement interdits pour l'exploitation de l'émetteur

3.3 *Japan*

3.3.1 *Notice for EVMs delivered in Japan:* Please see http://www.tij.co.jp/lsds/ti_ja/general/eStore/notice_01.page 日本国内に輸入される評価用キット、ボードについては、次のところをご覧ください。
http://www.tij.co.jp/lsds/ti_ja/general/eStore/notice_01.page

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If User uses EVMs in Japan, not certified to Technical Regulations of Radio Law of Japan, User is required by Radio Law of Japan to follow the instructions below with respect to EVMs:

1. Use EVMs in a shielded room or any other test facility as defined in the notification #173 issued by Ministry of Internal Affairs and Communications on March 28, 2006, based on Sub-section 1.1 of Article 6 of the Ministry's Rule for Enforcement of Radio Law of Japan,
2. Use EVMs only after User obtains the license of Test Radio Station as provided in Radio Law of Japan with respect to EVMs, or
3. Use of EVMs only after User obtains the Technical Regulations Conformity Certification as provided in Radio Law of Japan with respect to EVMs. Also, do not transfer EVMs, unless User gives the same notice above to the transferee. Please note that if User does not follow the instructions above, User will be subject to penalties of Radio Law of Japan.

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4.1 EVMS ARE NOT FOR USE IN FUNCTIONAL SAFETY AND/OR SAFETY CRITICAL EVALUATIONS, INCLUDING BUT NOT LIMITED TO EVALUATIONS OF LIFE SUPPORT APPLICATIONS.

4.2 User must read and apply the user guide and other available documentation provided by TI regarding the EVM prior to handling or using the EVM, including without limitation any warning or restriction notices. The notices contain important safety information related to, for example, temperatures and voltages.

4.3 *Safety-Related Warnings and Restrictions:*

4.3.1 User shall operate the EVM within TI's recommended specifications and environmental considerations stated in the user guide, other available documentation provided by TI, and any other applicable requirements and employ reasonable and customary safeguards. Exceeding the specified performance ratings and specifications (including but not limited to input and output voltage, current, power, and environmental ranges) for the EVM may cause personal injury or death, or property damage. If there are questions concerning performance ratings and specifications, User should contact a TI field representative prior to connecting interface electronics including input power and intended loads. Any loads applied outside of the specified output range may also result in unintended and/or inaccurate operation and/or possible permanent damage to the EVM and/or interface electronics. Please consult the EVM user guide prior to connecting any load to the EVM output. If there is uncertainty as to the load specification, please contact a TI field representative. During normal operation, even with the inputs and outputs kept within the specified allowable ranges, some circuit components may have elevated case temperatures. These components include but are not limited to linear regulators, switching transistors, pass transistors, current sense resistors, and heat sinks, which can be identified using the information in the associated documentation. When working with the EVM, please be aware that the EVM may become very warm.

4.3.2 EVMs are intended solely for use by technically qualified, professional electronics experts who are familiar with the dangers and application risks associated with handling electrical mechanical components, systems, and subsystems. User assumes all responsibility and liability for proper and safe handling and use of the EVM by User or its employees, affiliates, contractors or designees. User assumes all responsibility and liability to ensure that any interfaces (electronic and/or mechanical) between the EVM and any human body are designed with suitable isolation and means to safely limit accessible leakage currents to minimize the risk of electrical shock hazard. User assumes all responsibility and liability for any improper or unsafe handling or use of the EVM by User or its employees, affiliates, contractors or designees.

4.4 User assumes all responsibility and liability to determine whether the EVM is subject to any applicable international, federal, state, or local laws and regulations related to User's handling and use of the EVM and, if applicable, User assumes all responsibility and liability for compliance in all respects with such laws and regulations. User assumes all responsibility and liability for proper disposal and recycling of the EVM consistent with all applicable international, federal, state, and local requirements.

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